CAD-Game Engine Approach In Developing Real-world Walkthrough VR Application.

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Abstract

The use of 3D Game Engines to create real-world Walkthrough-Virtual Reality (VR) applications is a promising new alternative to currently available commercial VR packages. Although this new solution has been available for almost two years, it is still not well known and used as a serious VR application development tool. This paper describes the framework of developing a usable real-world Walkthrough-VR application utilising a Computer Aided Design (CAD) software and a 3D Game Engine. This application is concerned with the establishing of a prototype real-world Walkthrough-VR modeling system utilising CAD and the Game Engine. The integration between the two technologies enables the creation and sharing of a common geometrical database between them. By utilising VR technology, realistic virtual environment (VE) could be created from the CAD models for visualisation and evaluation purposes. The developed prototype can then be introduced to the present computer consumer market whereby its operator is normally the home, office and desktop PC user.

Keywords: CAD, 3D Game Engine, Virtual Reality, real-world Walkthrough-VR

1. Introduction

Nowadays, computers have been used in many ways to assist us in our daily routine tasks. In this early 21st century it is hard to envisage architects, engineers, interior designers, and even surgeons working without the assistance of a form of a graphic workstation. The rapid development of faster microprocessor has resulted not only faster central processing units or CPUs but also faster and better graphics display cards to be equipped as standard items in the computers. The encouraging growth in computer graphics has made it possible to even the average home-user to explore the world of computer graphics which includes Virtual Reality. This new virtual world often makes a start in the realm of computer games and from there onwards it usually lasts forever in other types of computer applications (Mazuryk, 1996).

In today's product development processes, computers and CAD packages play an important role in communicating the design intention of the designers and the clients. Computers can be used to create models that describe the objects' geometries and their physical properties within a 3-dimensional virtual space. The physical prototype which is based on the computer model for validation of forms, fits, and functions are then built (Creative Technical Solutions, 2000). CAD is the standard abbreviation for Computer Aided Design and also sometimes referred to as Computer Aided Drafting. CAD describes the use of computers to produce drawings

that would normally be prepared manually by pencils and papers. A CAD system is used to create 3D geometric models of objects, structures and assemblies (Runwal, 1998).

A computer game is any game that requires the use of a computer. Computer games are simply computer programs with instruction to accept input from a controller (usually either from a joystick, mouse or keyboard) and feed it back onto the screen. Computer games are interactive programs, which accept inputs from the user and in return inform the user of one status in the virtual environment. When one is playing a computer game, one is immersed into a virtual environment and is abide to the rules provided and the control aspects of the computer game (Jacobi, 1996). The control aspect can be in the form of turns or real-time. Real-time computer responses usually exist in action games where the action happens in a non-stop manner. The user continuously controls his virtual self or character to act accordingly as required in the virtual environment.

In the PC gaming industry, an entire virtual world is developed based on 3D Game Engine technology. Also in the CAD modeling world, a similar virtual environment can be built as well. The modeling technique utilising 3D Game Engine is by far differs from the traditional CAD modeling. Although similar 3D models can be produced by both techniques, the difference in modeling technique has become a hindrance to existing seasoned CAD users to learning new game design techniques that are mainly alien to them.

Since game engines are made to handle real-time interaction, it can only carry a limited amount of geometries that can be displayed on the monitor at one moment in time. It was discovered that to export a whole 3D CAD model was impossible because it carries a high amount of geometries or polygon counts. Several approaches were taken and it was found that it is possible to export the CAD model into the game environment in stages. The CAD geometries are firstly grouped according to objects or layers and then exported accordingly one group at a time.

The development of the VR world or VE can be divided into 3 main categories that is Study, Application Development and Prototype, with each consisting of sub-tasks (See Fig. 1). The main tasks and its sub-tasks formed the VE development framework. VR developers can refer to this framework as a guideline in developing low-cost, high performance and high quality VR visualisation.

2.0 Study

This category consists of one task that is the site/building investigation. Before this task is performed, an architect drawing or blueprint is referred to get an overview of the building and site measurements (See Fig. 2). Site investigation involves sub-tasks such as getting the image snapshots and measurements of building, identifying interactive and special effect elements to be included in the VE. The special effect elements are important since the 3D Game Engine has the ability to generate them realistically in real-time. Examples of special effect elements are water effect to represent the wavering water, lens flare effect, translucent mirror effect to make the marble floor shines and gives out reflection and multiple sky layer effect to enable cloud movement while stars and moon are stationary in the background.

3. Application Development

Before any development is started, some of the basic terminologies used in game development system have to be fully understood. Some of the common terms used are shown in Table 1.

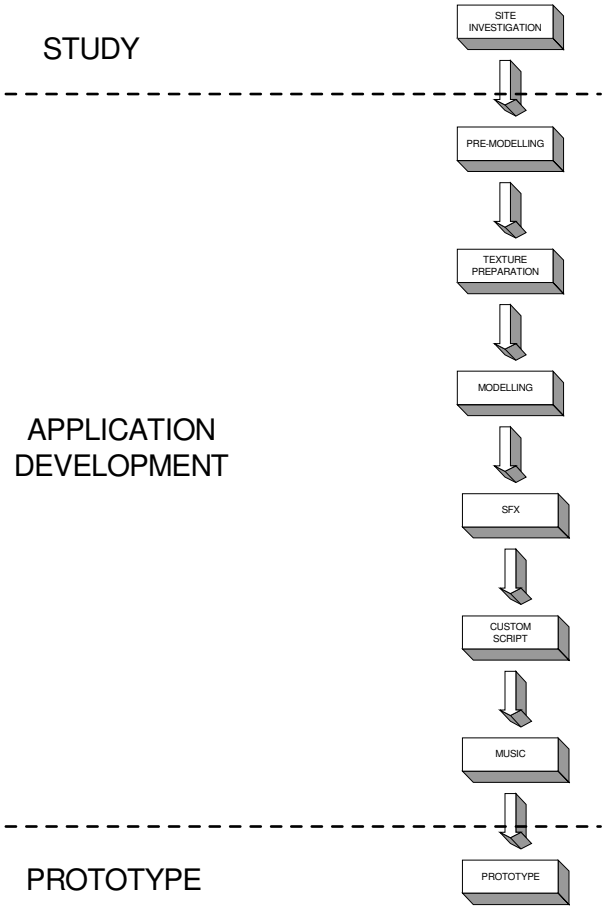

Fig. 1 Overview of the VE development framework

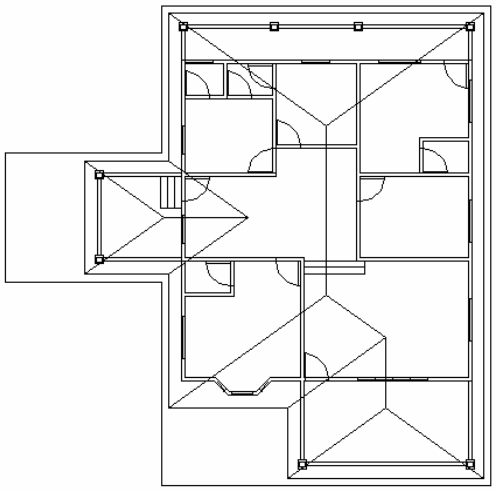

Fig. 2: Floor plan of building

Terms	Explanation
Object	Everything that is added to the level.
Brush	A geometric shape and it is the basic building blocks of the level.
Active Brush	Also known as the Red Brush or Building Brush.
Actor	Any non-brush object added to the level for example playerstarts, monsters, lights, inventory items, weapons and triggers.
Icon	An image used to represent an item.

Table 1. Basic Terminologies Used In Game Development System

3.1 Modeling Concept

It is also important to understand 3D Game modeling concept and how it works as the approach chosen is nevertheless the opposite of traditional CAD modeling. CAD modeling concept starts with a huge "EMPTY" space. Thus if one is to build a structure, one will have to "ADD" to that space. In contrast, 3D Game modeling concept starts with a huge "SOLID" block. This solid block does not have any empty or blank space in it. Hence, if a room is to be created in the virtual world, then the room is actually being "SUBTRACTED" from the solid block.

3.2 Elements of the Game Engine

Surrounding the 3D Game Engine are 6 main elements (Shiratuddin, 2000) (See Fig. 3). They are:

- 3D models / levels
- Textures
- AI characters
- Audio
- Real-time computer special-effects
- Behavioral scripts[1].

These elements surrounding the 3D Game Engine are removed and replaced by the Walkthrough-VR application elements. To represent a realistic virtual environment, high quality textures and material maps are used. Using a high-resolution digital camera, real pictures are captured, later edited and processed to create the required texture format supported by the game engine. Samples of the texture maps used are shown in Fig. 4.

3.3 CAD Modeling

Solid modeling technique is used to create the 3D CAD models. For simple prismatic components, they are extruded (extended along the z-axis) based on their 2D profiles. Boolean operation such as union and subtract are also used. On the other hand, complex 3D components and structures used a combination of extrusion, union and subtract operations. To easily manage and avoid crashes, the 3D geometries are grouped according to objects and layers and then exported one group at a time into the 3D Game Engine development environment.

[1] E.g. when user is within a close proximity of a door, the door opens, user can interact with light and fan switches etc. AI characters may have scripts attached to it.

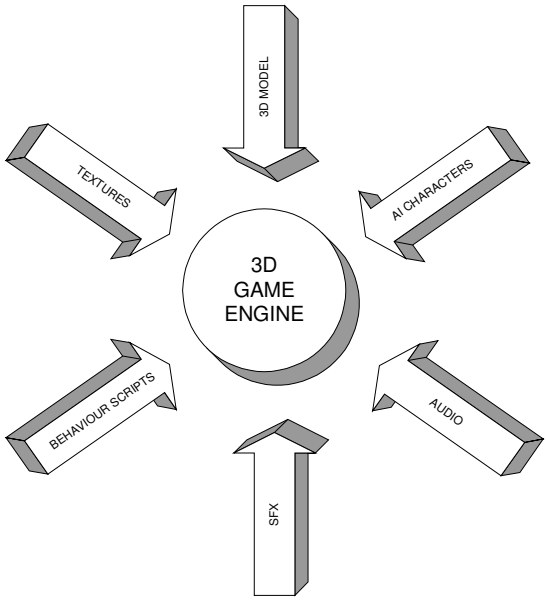

Fig. 3 Elements surrounding a 3D game engine

Fig. 4 Sample of real texture maps

3.4 Audio

All computer games have music. The 3D Game Engine can import from an external source, a different number of digital music format (See Table 2). Soothing sentimental background music can be added to the level to enhance the enjoyment and virtual experience of the user.

Music Format Extension	Music Format Type
MOD	Amiga Modules
STM	ScreamTracker 3
S3M	ScreamTracker 2
XM	Fasttracker
IT	Impulse Tracker
FAR	Farandale
669	ComposD
MP3	MPEG Layer-3

Table 1: Supported Digital Audio Format

3.5 Lightings

Lighting plays an important role in creating a realistic virtual environment. Without the right lighting settings, the environment will not be convincing. In order for the virtual environment to be seen and perceived clearly, there must be a difference in brightness between the foreground and background (Zulkifli and Shiratuddin, 2001). Darkness that represents shadows not only can assists in defining space, but through contrast, it expands the sense of scale and emphasises the sculptural quality of any object being illuminated (See Fig. 5 and 6). All the required lighting conditions are present in the game engine.

Fig. 5: A room with dull lighting level.

Fig. 6: A room with dynamic lighting.

3.6 Interactivity

The 3D Game Engine supports quite a number of interactive components such as lift, light ON/OFF, moving objects and banners. An example of an interactive element which is added into the prototype virtual environment is the interactive door. This door will automatically open whenever the user is within close proximity of the trigger switch.

4. Prototype

In analysing the prototype system requirements, several factors are considered. The factors are:

4.1 Users requirement

The virtual environment must allow users to participate in the 3-dimensional virtual environment. This enables them to freely walkthrough and around the environment at their own pace to gain a higher level of understanding of the environment. They must be able to realistically experience how the environment appears and make selections and changes without any constraint (Zulkifli et al., 2000).

4.2 Hardware requirement

The hardware used for the prototype system is a PC-based computer with Windows 95 as the operating system. It has random access memory of 128 MB and built-on-board graphic card of 4MB. A mouse is used to manuevure inside the virtual environment. The virtual reality system used is categorised as a desktop virtual reality system.

4.3 Software requirement

AutoCad release 14 is the CAD system used to model the prototype house. The house was created in 3D by using the solid modeling technique. For the virtual reality application, Unreal was used to create the virtual environment. Unreal was chosen because of its ability to read .DXF files, thus enabling an integration between CAD and Unreal applications. Finally with all the required elements in placed, the prototype was completed. Fig. 7, 8 and 9 show various angle of views of the prototype virtual house.

Fig. 7 Front view of the prototype house.

Fig. 8 Rear view of the prototype house.

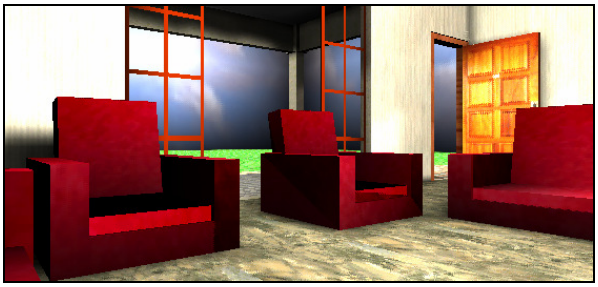

Fig. 9 Interior view of the prototype house.

5. Conclusion

It is now an acknowledged experience that synthetic worlds generated wholly in the computers can stimulate our senses (Webster, 1999) therefore a Walkthrough-VR experience is as almost as real as the physical experience. From the successfully developed prototype, it can be seen that by utilising the above technique, the virtual experience is enhanced in terms of real-time realistic representation and good visual quality. It has also proven that a good VR application can be developed only using a low-cost desktop computer system with minimal PC software and hardware requirements (Zulkifli and Shiratuddin, 2001).

The designing concept is able to enhance real-time visualisation applications. The virtual environment constructed provides the indefinite architectural possibilities and gives the users (client and designer) the contentment they need to virtually experience it (Patel, 1994). In the case of utilising the 3D Game Engine coupled with a CAD model, the time to render and re-render the geometries with full texture and lighting support will only take minutes instead of hours or days like the one present in CAD and 3D modeling packages (Miliano, 1999).

The ability to integrate CAD and 3D Game Engine in developing a low-cost, high-performance VR application is beneficial especially for those directly involved in the construction industry such as architects, engineers, interior designers and real estate developers.

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